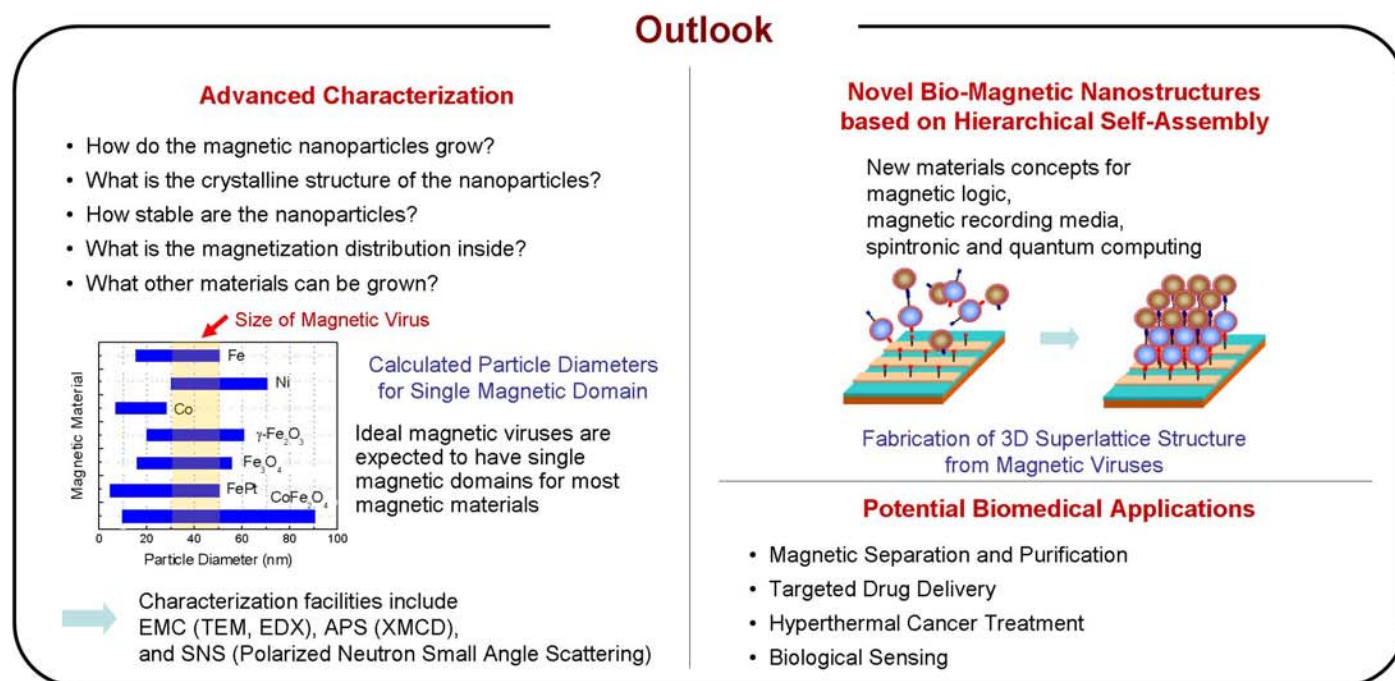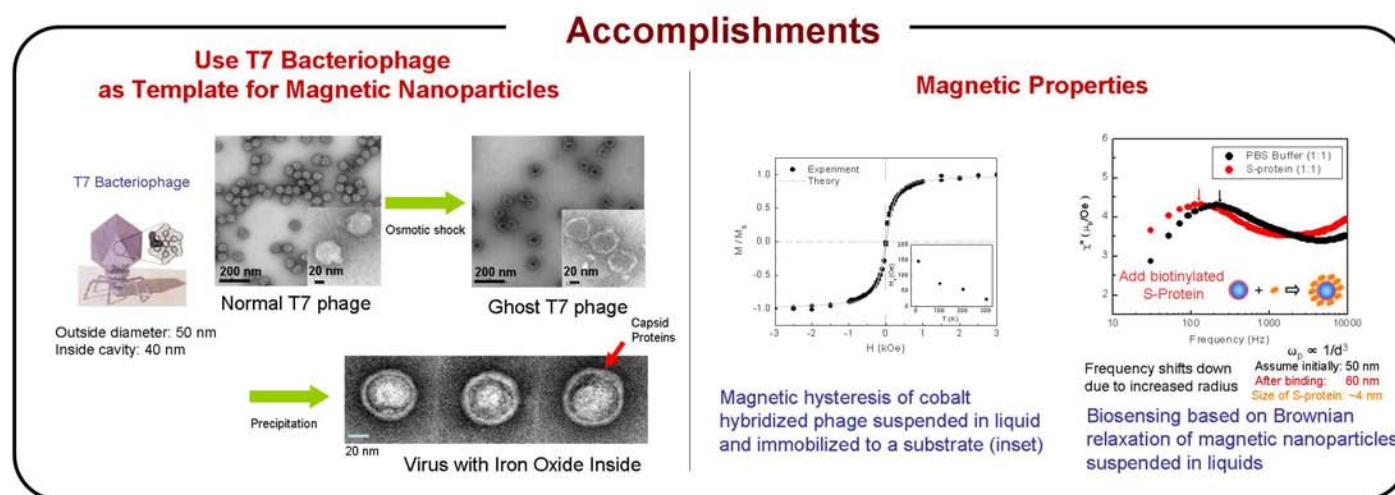# Magnetic Viruses via Nano-Capsid Templates

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Motivation

Biology + Magnetism → Magnetic Virus → New Bio-Inorganic Concept

- Building block for new biomaterials using hierarchical self-assembly
- Well defined biological recognition
- Monodisperse size distribution → uniform magnetic property

Accomplishments

Use T7 Bacteriophage as Template for Magnetic Nanoparticles

T7 Bacteriophage

Osmotic shock

200 nm 20 nm Normal T7 phage

200 nm 20 nm Ghost T7 phage

Outside diameter: 50 nm
Inside cavity: 40 nm

Precipitation

20 nm

Capsid Proteins

Virus with Iron Oxide Inside

Magnetic Properties

Magnetic hysteresis of cobalt hybridized phage suspended in liquid and immobilized to a substrate (inset)

Add biotinylated S-Protein

Frequency shifts down due to increased radius

$\omega_p \propto 1/d^3$

Assume initially: 50 nm
After binding: 60 nm
Size of S-protein: ~4 nm

Biosensing based on Brownian relaxation of magnetic nanoparticles suspended in liquids

Outlook

Advanced Characterization

- How do the magnetic nanoparticles grow?
- What is the crystalline structure of the nanoparticles?
- How stable are the nanoparticles?
- What is the magnetization distribution inside?
- What other materials can be grown?

Size of Magnetic Virus

Calculated Particle Diameters for Single Magnetic Domain

Ideal magnetic viruses are expected to have single magnetic domains for most magnetic materials

Characterization facilities include EMC (TEM, EDX), APS (XMCD), and SNS (Polarized Neutron Small Angle Scattering)

Novel Bio-Magnetic Nanostructures based on Hierarchical Self-Assembly

New materials concepts for magnetic logic, magnetic recording media, spintronic and quantum computing

Fabrication of 3D Superlattice Structure from Magnetic Viruses

Potential Biomedical Applications

- Magnetic Separation and Purification
- Targeted Drug Delivery
- Hyperthermal Cancer Treatment
- Biological Sensing